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DESCRIPTION

POLISHING APPARATUS

Technical Field

The present invention relates to a polishing apparatus, and more particularly to a polishing apparatus for polishing a workpiece to be polished, such as a semiconductor wafer, by holding the workpiece and pressing the workpiece against a polishing surface.

Background Art

In recent years, semiconductor devices have become more integrated, and structures of semiconductor elements have become more complicated. Further, the number of layers in multilayer interconnections used for a logical system has been increased. Accordingly, irregularities on a surface of a semiconductor device are increased, so that step heights on the surface of the semiconductor device tend to be large. This is because, in a manufacturing process of a semiconductor device, a thin film is formed on a semiconductor device, then micromachining processes, such as patterning or forming holes, are performed on the semiconductor device, and these processes are repeated to form subsequent thin films on the semiconductor device.

When the number of irregularities is increased on a surface of a semiconductor device, the following problems arise. When a thin film is formed on a semiconductor device, the thickness of the film formed at portions having a step becomes small. Further, an open circuit may be caused by disconnection, or a short circuit may be caused by insufficient insulation between interconnection layers. As a result, good products cannot be obtained, and the yield tends to be lowered. Further, even if a

ATTACHMENT B

semiconductor device initially works normally, reliability of the semiconductor device is lowered after a long-term use. At the time of exposure in a lithography process, if the irradiation surface has irregularities, then a lens unit in an exposure system is locally unfocused. Therefore, if the irregularities on the surface of the semiconductor device are increased, then it becomes problematically difficult to form a fine pattern itself on the semiconductor device.

Thus, in a manufacturing process of a semiconductor device, it increasingly becomes important to planarize a surface of the semiconductor device. One of the most important planarizing technologies is chemical mechanical polishing (CMP). In a chemical mechanical polishing, while a polishing liquid containing abrasive particles such as silica (SiO_2) therein is supplied onto a polishing surface such as a polishing pad, a substrate such as a semiconductor wafer is brought into sliding contact with the polishing surface, so that the substrate is polished.

This type of polishing apparatus includes a polishing table having a polishing surface formed by a polishing pad and a top ring for holding a semiconductor wafer. When a semiconductor wafer is polished with such a polishing apparatus, the semiconductor wafer is held and pressed against the polishing table under a predetermined pressure by the top ring. At that time, the polishing table and the top ring are moved relative to each other to bring the semiconductor wafer into sliding contact with the polishing surface, so that the surface of the semiconductor wafer is polished to a flat mirror finish.

The polishing pad is so elastic that pressing forces applied to a peripheral edge portion of the semiconductor wafer tend to be non-uniform. Accordingly, the semiconductor wafer may excessively be polished only at the peripheral edge portion to thus cause edge rounding. In order to prevent such edge rounding, as shown in FIG. 1, there has been employed a top ring

having a structure for holding a side edge portion of a semiconductor wafer W by a retainer ring 600 and pressing a polishing surface 610 located outside of a peripheral edge portion of the semiconductor wafer W by the retainer ring 600. In this type of top ring, as shown in FIG. 1, the retainer ring 600 is fixed to a peripheral portion of a disk-like housing (flange portion) 620 and pressed against the polishing surface 610 under a pressing force applied by a top ring shaft 630, which is connected to a central portion of the housing 620.

In the aforementioned conventional top ring, since the retainer ring 600 and the housing 620 are rigidly connected to each other, as shown in FIG. 1, a bending moment M_0 is produced in the housing 620 and the retainer ring 600 due to a pressing force of the top ring shaft 630 which is applied to a central portion of the housing 620. Accordingly, the retainer ring 600 is inclined by deformation due to the bending moment M_0. When the retainer ring 600 is thus inclined, the surface pressure is not constant on the lower surface of the retainer ring 600. Therefore, the retainer ring 600 is partially worn. For this reason, highly accurate polishing cannot be achieved.

Specifically, in order to improve a polishing performance, a portion for pressing a workpiece W to be polished tends to have a complicated structure. Since the top ring has a complicated pressing mechanism, a portion at which the retainer ring 600 is attached to the housing 620 is separated from an outer peripheral edge of the workpiece W in a circumferential direction so as to form an overhanging portion in view of structural mechanics. A bending moment M_0 produced by the overhanging deforms the retainer ring 600 as shown in FIG. 1 so that the surface pressure of the retainer ring 600 to the polishing surface 610 becomes non-uniform. If the retainer ring 600 is partially worn according to progress of polishing time, then a polishing profile varies so as to exert an adverse influence on polishing stability.

Thus, in the aforementioned polishing apparatus, the retainer ring

600 for holding a peripheral portion of the workpiece W is required to have a function to uniformly press the polishing surface 610 of the polishing table in addition to a function to hold the workpiece W.

Disclosure of Invention

The present invention has been made in view of the above drawbacks. It is, therefore, a first object of the present invention to provide a polishing apparatus which can prevent or reduce partial wear of a retainer ring during polishing so as to conduct highly accurate polishing.

A second object of the present invention is to provide a polishing apparatus which can reduce cost for expendables and environment loads, enhance reliability, and shorten a period of time required to conduct dummy polishing after a new retainer ring is attached to a housing.

A third object of the present invention is to provide a retainer ring which allows dummy polishing, which has been required to be performed on a polishing apparatus, to be performed on a separate dedicated apparatus or machine tool.

In order to attain the first object, according to a first aspect of the present invention, there is provided a polishing apparatus having a polishing surface, a top ring for holding a workpiece to be polished, and a top ring shaft for pressing the top ring against the polishing surface. The top ring has a retainer ring for holding a peripheral edge portion of the workpiece, a housing substantially in a form of a disk which is connected to the top ring shaft, and a sliding contact joint interconnecting the retainer ring and the housing in a state such that the retainer ring and the housing are brought into sliding contact with each other.

With such an arrangement, when the top ring is pressed against the polishing surface, the retainer ring and the housing are brought into sliding

contact with each other. Accordingly, even if the top ring shaft applies a load to a central portion of the housing, only a vertical component of the load is transmitted to the retainer ring while no bending moment is applied to the retainer ring because the housing and the retainer ring slide with respect to each other. As a result, the retainer ring is not tilted due to a bending moment. Thus, it is possible to prevent partial wear from being caused on a lower surface of the retainer ring.

The sliding contact joint may comprise a free joint, preferably a ball joint, to bring the retainer ring and the housing into sliding contact with each other.

According to a second aspect of the present invention, there is provided a polishing apparatus having a polishing surface, a top ring for holding a workpiece to be polished, and a top ring shaft for pressing the top ring against the polishing surface. The top ring has a retainer ring for holding a peripheral edge portion of the workpiece, a housing substantially in a form of a disk which is connected to the top ring shaft, and a joint interconnecting the retainer ring and the housing. The joint has a sufficient high rigidity in horizontal and vertical directions and a low flexural rigidity.

Thus, since the rigidity of the joint is increased in the horizontal and vertical directions, a load can reliably be transmitted from the top ring shaft to the retainer ring. Further, since the flexural rigidity of the joint is lowered, a bending moment due to a load applied to a central portion of the housing can be absorbed by the joint to reduce a bending moment applied to the retainer ring. Accordingly, it is possible to prevent inclination of the retainer ring and reduce partial wear of the lower surface of the retainer ring.

It is desirable that the joint is disposed outside of a center of a radial width of the retainer ring. When the joint is disposed outside of the center of the radial width of the retainer ring, a load of the top ring shaft is applied to a

portion located outside of the center of the radial width of the retainer ring. Accordingly, a bending moment is produced with respect to the center of the width of the retainer ring. This bending moment cancels a bending moment produced by a load applied to the central portion of the housing. Thus, a bending moment applied to the retainer ring 3 can further be reduced. Accordingly, it is possible to reduce partial wear of the lower surface of the retainer ring more effectively. The joint may have a cross-section constricted at a vertically central portion thereof.

According to a third aspect of the present invention, there is provided a polishing apparatus having a polishing surface, a top ring for holding a workpiece to be polished, and a top ring shaft for pressing the top ring against the polishing surface. The top ring has a retainer ring for holding a peripheral edge portion of the workpiece and a housing substantially in a form of a disk which is connected to the top ring shaft. A rigidity of the housing is increased so that an inclination of a lower surface of the retainer ring is reduced with respect to the polishing surface when the top ring is pressed against the polishing surface.

For example, the housing may be made of a material having high strength and rigidity, such as metal or ceramics, and thickened so as to have a high rigidity. Thus, when the housing has a high rigidity, a bending moment becomes unlikely to be applied to the retainer ring even if a load is applied to the central portion of the housing by the top ring shaft. Accordingly, it is possible to prevent partial wear of the retainer ring.

In order to attain the second object, according to a fourth aspect of the present invention, there is provided a polishing apparatus for polishing a workpiece to be polished, such as a semiconductor wafer, to a flat mirror finish. The polishing apparatus has a polishing surface and a top ring for holding a workpiece to be polished. The top ring has a retainer ring for

holding a peripheral edge portion of the workpiece. The retainer ring has a first ring member made of resin, a second ring member made of metal or ceramic, and a fastening tool for fastening the first ring member and the second ring member in a manner such that the first ring member and the second ring member can be detached as two layers in a vertical direction.

With such an arrangement, it is possible to enhance the reliability of fastening the first ring member and the second ring member. Further, the retainer ring can be regenerated merely by replacement of a worn first ring member. Accordingly, it is possible to reduce cost for expendables. Furthermore, when the retainer ring is attached to a lower surface of a peripheral portion of the housing by a detachable fastening tool, a clamp stress is received by the second ring member such as metal or ceramics, which has a high rigidity. Thus, the retainer ring is prevented from being deformed. Therefore, it is possible to shorten a period of time, i.e., downtime, required for a dummy polishing process.

It is desirable that the first ring member is brought into contact with the polishing surface. It is also desirable that the first ring member includes particles serving as abrasive particles when the first ring member is scraped. In this case, particles scraped from the first ring member of the retainer ring serve as abrasive particles. Thus, abrasive particles are supplied from the retainer ring by supplying, e.g., pure water to the polishing surface.

It is desirable that the retainer ring further includes an engagement portion to fit the first ring member and the second ring member into each other. With such an arrangement, it is possible to facilitate assembling the retainer ring and further enhance the reliability of fastening the first ring member and the second ring member.

The retainer ring is preferably configured such that the retainer ring can be regenerated only by replacement of the first ring member. Since the

retainer ring can be regenerated merely by replacement of the first ring member, it is possible to reduce cost for expendables and environment loads.

It is desirable that the fastening tool comprises a bolt. When a bolt is used as the fastening tool, it is possible to facilitate fastening, assembling, and disassembling the first ring member and the second ring member.

In order to attain the third object, according to a fifth aspect of the present invention, there is provided a retainer ring for holding a peripheral edge portion of a workpiece to be polished, which is held on a substrate holding surface of a top ring. The retainer ring has a first ring member made of resin, a second ring member made of metal or ceramic, and a fastening tool for fastening the first ring member and the second ring member in a manner such that the first ring member and the second ring member can be detached as two layers in a vertical direction. The first ring member is polished to have flatness.

Thus, the first ring member and the second ring member can be fastened by a detachable fastening tool to form a retainer ring having a two-layer structure in the vertical direction. Then, the first ring member can be polished so as to have flatness. Accordingly, it is not necessary to conduct dummy polishing on the polishing apparatus which has heretofore been required.

Brief Description of Drawings

FIG. 1 is a schematic view showing a conventional top ring;

FIG. 2 is a schematic view showing an entire arrangement of a polishing apparatus according to a first embodiment of the present invention;

FIG. 3 is a vertical cross-sectional view of a top ring in the polishing apparatus shown in FIG. 2 on a cutting plane;

FIG. 4 is a vertical cross-sectional view of the top ring in the polishing

apparatus shown in FIG. 2 on another cutting plane;

FIG. 5 is a plan view showing a sliding contact joint (housing) of the top ring shown in FIG. 3;

FIG. 6 is a vertical cross-sectional view showing a variation of the top ring shown in FIG. 3;

FIG. 7 is a vertical cross-sectional view showing a top ring according to a second embodiment of the present invention;

FIG. 8 is a schematic view showing the top ring shown in FIG. 7;

FIG. 9 is a vertical cross-sectional view showing a top ring according to a third embodiment of the present invention;

FIG. 10A is a vertical cross-sectional view showing an attachment portion of a retainer ring of the top ring shown in FIG. 9;

FIG. 10B is a view showing a surface pressure distribution in the retainer ring shown in FIG. 10A;

FIG. 11 is a plan view showing an example of an arrangement of bolts in the retainer ring shown in FIG. 9;

FIG. 12 is a plan view showing another example of an arrangement of bolts in the retainer ring shown in FIG. 9;

FIG. 13A is a vertical cross-sectional view showing an attachment portion of a conventional retainer ring;

FIG. 13B is a view showing a surface pressure distribution in the retainer ring shown in FIG. 13A;

FIG. 14 is a vertical cross-sectional view showing a top ring according to a fourth embodiment of the present invention;

FIG. 15 is a cross-sectional view showing a variation of the top ring shown in FIG. 14;

FIG. 16 is a cross-sectional view showing a variation of the top ring shown in FIG. 14;

FIG. 17A is an enlarged cross-sectional view of a main portion of a top ring according to a fifth embodiment of the present invention;

FIG. 17B is an enlarged cross-sectional view of a main portion of a top ring according to a sixth embodiment of the present invention;

FIGS. 18A and 18B are enlarged cross-sectional views showing variations of the retainer ring shown in FIG. 14;

FIG. 19 is an enlarged cross-sectional view showing a variation of the retainer ring shown in FIG. 14; and

FIG. 20 is a graph showing a surface pressure distribution along a radial direction of a lower surface of the retainer ring shown in FIG. 17B.

Best Mode for Carrying Out the Invention

Embodiments of a polishing apparatus according to the present invention will be described below with reference to FIGS. 2 through 20. In FIGS. 2 through 20, like or corresponding parts are denoted by like or corresponding reference numerals and will not be described below repetitively.

FIG. 2 is a schematic view showing an entire arrangement of a polishing apparatus according to a first embodiment of the present invention. As shown in FIG. 2, a polishing table 100 having a polishing pad 101 attached to an upper surface thereof is provided below a top ring 1. Further, a polishing liquid supply nozzle 102 is provided above the polishing table 100. A polishing liquid Q is supplied from the polishing liquid supply nozzle 102 to the polishing pad 101 on the polishing table 100.

Various kinds of polishing pads are available on the market. For example, some of these are SUBA800, IC-1000, and IC-1000/SUBA400 (two-layer cloth) manufactured by Rodel Inc., and Surfin xxx-5 and Surfin 000

manufactured by Fujimi Inc. SUBA800, Surfin xxx-5, and Surfin 000 are non-woven fabrics bonded by urethane resin, and IC-1000 is made of hard rigid foam polyurethane (single layer). Foam polyurethane is porous and has a large number of fine recesses or holes formed in its surface.

The top ring 1 is connected to a top ring shaft 11 via a universal joint 10, and the top ring shaft 11 is coupled to a top ring air cylinder 111 fixed to a top ring head 110. The top ring 1 has a housing 2 (flange portion) substantially in the form of a disk, which is coupled to a lower end of the top ring shaft 11, and a retainer ring 3 disposed at a peripheral portion of the housing 2.

The top ring air cylinder 111 is connected to a pressure adjustment unit 120 via a regulator R1. The pressure adjustment unit 120 serves to adjust a pressure by supply of a pressurized fluid such as pressurized air from a compressed air source or by evacuation with pump or the like The air pressure of the pressurized air to be supplied to the top ring air cylinder 111 is adjusted via the regulator R1 by the pressure adjustment unit 120. The top ring air cylinder 111 moves the top ring shaft 11 vertically to raise and lower the whole top ring 1 and press the retainer ring 3 attached to the housing 2 against the polishing table 100 under a predetermined pressing force.

The top ring shaft 11 is coupled to a rotary sleeve 112 by a key (not shown). The rotary sleeve 112 has a timing pulley 113 disposed at a peripheral portion thereof. A top ring motor 114 is fixed to the top ring head 110. The timing pulley 113 is connected to a timing pulley 116 mounted on the top ring motor 114 via a timing belt 115. Accordingly, when the top ring motor 114 is energized for rotation, the rotary sleeve 112 and the top ring shaft 11 are rotated in unison with each other via the timing pulley 116, the timing belt 115, and the timing pulley 113 to thereby rotate the top ring 1.

The top ring head 110 is supported on a top ring head shaft 117 rotatably supported on a frame (not shown).

The top ring 1 will be described in greater details. FIG. 3 is a vertical cross-sectional view of the top ring 1 shown in FIG. 2 on a cutting plane, FIG. 4 is a vertical cross-sectional view of the top ring 1 shown in FIG. 2 on another cutting plane, and FIG. 5 is a plan view showing the housing 2 of the top ring 1 shown in FIG. 3.

As shown in FIGS. 3 and 4, the retainer ring 3 has an upper member 3a substantially in the form of a cylinder and a lower member 3b substantially in the form of a cylinder. The lower member 3b has a lower portion projecting inward. As shown in FIGS. 3 and 5, ball joints 4 are provided as free joints to bring the retainer ring 3 and the housing 2 into sliding contact with each other at a plurality of locations in a circumferential direction of the retainer ring 3 on an upper portion of the upper member 3a of the retainer ring 3. The ball joints 4 are interposed between hemispherical recesses 2a formed in a lower surface of the housing 2 and hemispherical recesses 3c formed in an upper surface of the upper member 3a of the retainer ring 3.

As shown in FIGS. 4 and 5, connection bolts 5 are provided on an upper portion of the upper member 3a of the retainer ring 3 at a plurality of locations in the circumferential direction. The housing 2 has spring receivers 2b corresponding to the connection bolts 5. Coil springs 6 are interposed between the connection bolts 5 and the spring receivers 2b. Thus, the ball joints 4, the connection bolts 5, the spring receivers 2b, and the coil springs 6 jointly form sliding contact joints to interconnect the retainer ring 3 and the housing 2 in a state such that the retainer ring 3 and the housing 2 are brought into sliding contact with each other. In the present embodiment, the retainer ring 3 and the housing 2 are brought into sliding contact with

each other by the ball joints 4. However, any means can be used as long as it brings the retainer ring 3 and the housing 2 into sliding contact with each other.

As described above, the top ring shaft 11 is disposed above a central portion of the housing 2, and the housing 2 is coupled to the top ring shaft 11 by the universal joint 10. The universal joint 10 has a spherical bearing mechanism by which the housing 2 and the top ring shaft 11 are tiltable with respect to each other, and a rotation transmitting mechanism for transmitting rotation of the top ring shaft 11 to the housing 2. These mechanisms transmit a pressing force and a rotating force from the top ring shaft 11 to the housing 2 while allowing the housing 2 and the top ring shaft 11 to be tilted with respect to each other.

The spherical bearing mechanism includes a hemispherical recess 11a defined centrally in a lower surface of the top ring shaft 11, a hemispherical recess 2c defined centrally in an upper surface of the housing 2, and a bearing ball 12 made of a highly hard material such as ceramics and interposed between the recesses 11a and 2c. As shown in FIG. 3, connection bolts 7 are mounted near the top ring shaft 11 of the housing 2. Coil springs 8 are interposed between the connection bolts 7 and spring receivers 11b provided in the top ring shaft 11. With such a structure, the housing 2 is held so as to be tiltable with respect to the top ring shaft 11.

Meanwhile, the rotation transmitting mechanism includes engagement pins 9 fixed to the housing 2 near the top ring shaft 11 and engagement holes 11c formed in the top ring shaft 11. Even if the housing 2 is tilted with respect to the top ring shaft 11, the engagement pins 9 remain in engagement with the engagement holes 11c while contact points are displaced because the engagement pins 9 are vertically movable through the engagement holes 11c. Thus, the rotation transmitting mechanism reliably

transmits rotational torque of the top ring shaft 11 to the housing 2.

The housing 2 and the retainer ring 3 have a space defined therein, which accommodates therein an elastic pad 20 brought into contact with the semiconductor wafer W held by the top ring 1, an annular holder ring 21, and a chucking plate 22 substantially in the form of a disk for supporting the elastic pad 20. The elastic pad 20 has a radially outer edge clamped between the holder ring 21 and the chucking plate 22 fixed to a lower end of the holder ring 21 and covers a lower surface of the chucking plate 22. Thus, a pressure chamber 30 is defined between the elastic pad 20 and the chucking plate 22. The elastic pad 20 is made of a highly strong and durable rubber material such as ethylene propylene rubber (EPDM), polyurethane rubber, or silicone rubber.

An opening 22a is formed at a central portion of the chucking plate 22. A fluid passage 40 comprising tubes and connectors communicate with the opening 22a, which is connected to the pressure adjustment unit 120 via a regulator R2 provided on the fluid passage 40. Specifically, the pressure chamber 30 between the elastic pad 20 and the chucking plate 22 is connected to the pressure adjustment unit 120 via the regulator R2 provided on the fluid passage 40.

A pressurizing sheet 23 comprising an elastic membrane extends between the holder ring 21 and the housing 2. The pressurizing sheet 23 has one end clamped by a pressurizing sheet support 2d mounted to a lower surface of the housing 2 and another end clamped between an upper end portion 21a and a stopper portion 21b of the holder ring 21. The housing 2, the chucking plate 22, the holder ring 21, and the pressurizing sheet 23 jointly define a pressure chamber 31 in the housing 2. As shown in FIG. 3, a fluid passage 41 comprising tubes and connectors communicates with the pressure chamber 31, which is connected to the pressure adjustment unit 120

via a regulator R3 provided on the fluid passage 41. The pressurizing sheet 23 is made of a highly strong and durable rubber material such as ethylene propylene rubber (EPDM), polyurethane rubber, or silicone rubber.

The pressure chamber 30 between the chucking plate 22 and the elastic pad 20 and the pressure chamber 31 above the chucking plate 22 are respectively supplied with pressurized fluids such as pressurized air, released to an atmospheric pressure, or evacuated, via the fluid passages 40 and 41 connected to the pressure chambers 30 and 31. Specifically, as shown in FIG. 2, the regulators R2 and R3 provided on the fluid passages 40 and 41 of the pressure chambers 30 and 31 can respectively regulate pressures of the pressurized fluids to be supplied to the respective pressure chambers. Thus, it is possible to independently control the pressures in the pressure chambers 30 and 31 or independently introduce atmospheric air or vacuum into the pressure chambers 30 and 31.

Further, the chucking plate 22 has inner suction portions 24 and outer suction portions 25 projecting downward outside of the opening 22a. The inner suction portions 24 have communication holes 24a communicating with a fluid passage 42, which comprises tubes and connectors. The inner suction portions 40 are connected to the pressure adjustment unit 120 via a regulator R4 provided on the fluid passage 42. Similarly, the outer suction portions 25 have communication holes 25a communicating with a fluid passage 43, which comprises tubes and connectors. The outer suction portions 25 are connected to the pressure adjustment unit 120 via a regulator R5 provided on the fluid passage 43. Negative pressures can be developed at opening ends of the communication holes 24a and 25a of the suction portions 24 and 25 by the pressure adjustment unit 120, thereby attracting a semiconductor wafer W to the suction portions 24 and 25. The suction portions 24 and 25 have elastic sheets, such as thin rubber sheets, attached to

their lower ends, to thereby softly attract and hold the semiconductor wafer W.

As shown in FIG. 3, a cleaning liquid passage 26 is formed in the upper member 3a of the retainer ring 3. The cleaning liquid passage 26 communicates with a slight gap between an outer circumferential surface of the elastic pad 20 and the lower member 3b of the retainer ring 3. A cleaning liquid (pure water) is supplied to the gap through the cleaning liquid passage 26.

In the polishing apparatus thus constructed, when a semiconductor wafer W to be delivered, the entire top ring 1 is moved to a transferring location of the semiconductor wafer. Then, the communication holes 24a and 25a of the suction portions 24 and 25 are connected to the pressure adjustment unit 120 via the fluid passages 42 and 43. The semiconductor wafer W is attracted under vacuum to the lower ends of the suction portions 24 and 25 by suction effect of the communication holes 24a and 25a. While the semiconductor wafer W is attracted to the suction portions, the entire top ring 1 is moved to a position above the polishing table 100 having the polishing surface (polishing pad 101) thereon. The outer circumferential edge of the semiconductor wafer W is held by the retainer ring 3 so that the semiconductor wafer W is not removed from the top ring 1.

For polishing, the attraction of the semiconductor wafer W by the suction portions 24 and 25 is released, and the semiconductor wafer W is held on the lower surface of the top ring 1. Simultaneously, the top ring air cylinder 111 connected to the top ring shaft 11 is actuated to press the retainer ring 3 fixed to the lower end of the top ring 1 against the polishing surface on the polishing table 100 under a predetermined pressing force. In such a state, a pressurized fluid having a predetermined pressure is supplied to the pressure chamber 30 to thereby press the semiconductor wafer W

against the polishing surface on the polishing table 100. The polishing liquid supply nozzle 102 supplies a polishing liquid Q onto the polishing pad 101 in advance, so that the polishing liquid Q is held on the polishing pad 101. Thus, the semiconductor wafer W is polished with the polishing liquid Q being present between the (lower) surface, to be polished, of the semiconductor wafer W and the polishing pad 101.

When a pressurized fluid is supplied to the pressure chamber 30, an upward force is applied to the chucking plate 22. Accordingly, in the present embodiment, a pressure fluid is supplied to the pressure chamber 31 through the fluid passage 41 to prevent the chucking plate 22 from being lifted by forces from the pressure chamber 31.

As described above, the pressing force applied by the top ring air cylinder 111 to press the retainer ring 3 against the polishing pad 101 and the pressing force applied by the pressurized air supplied to the pressure chamber 30 to press the semiconductor wafer W against the polishing pad 101 are appropriately adjusted to polish the semiconductor wafer W. When the polishing of the semiconductor wafer W is finished, the semiconductor wafer W is attracted to the lower ends of the suction portions 24 and 25 under vacuum. At that time, the supply of the pressurized fluid into the pressure chamber 30 to press the semiconductor wafer W against the polishing surface is stopped, and the pressure chamber 30 is vented to the atmosphere. Accordingly, the lower ends of the suction portions 24 and 25 are brought into contact with the semiconductor wafer W. The pressure chamber 31 is vented to the atmosphere or evacuated to develop a negative pressure therein. If the pressure chamber 31 is maintained at a high pressure, then the semiconductor wafer W is strongly pressed against the polishing surface only in areas brought into contact with the suction portions 40.

After attraction of the semiconductor wafer W, the entire top ring 1 is

moved to a transferring position of the semiconductor wafer W, and then a fluid (e.g., compressed air or a mixture of nitrogen and pure water) is ejected to the semiconductor wafer W via the communication holes 24a and 25a of the suction portions 24 and 25 to release the semiconductor wafer W from the top ring 1.

As described above, in the present embodiment, when the top ring 1 is pressed against the polishing surface, the retainer ring 3 and the housing 2 are brought into sliding contact with each other by the ball joints 4. Accordingly, even if the top ring shaft 11 applies a load to the central portion of the housing 2, only a vertical component of the load is transmitted to the retainer ring 3 while no bending moment is applied to the retainer ring 3 because the housing 2 and the retainer ring 3 slide with respect to each other. As a result, the retainer ring 3 is not tilted due to a bending moment. Thus, it is possible to prevent partial wear from being caused on a lower surface of the retainer ring 3.

Here, the aforementioned bending moment can also be prevented from being applied to the retainer ring 3 by enhancing a rigidity of the housing 2. For example, the housing 2 may be made of a material having high strength and rigidity, such as metal or ceramics, and thickened so as to have a high rigidity. Thus, an inclination of the lower surface of the retainer ring 3 with respect to the polishing pad 101 is reduced when the top ring 1 is pressed against the polishing pad 101. When the housing 2 has a high rigidity, a bending moment becomes unlikely to be applied to the retainer ring 3 even if a load is applied to the central portion of the housing 2 by the top ring shaft 11. Accordingly, it is possible to prevent partial wear of the retainer ring 3.

In the present embodiment, the aforementioned sliding contact joints can eliminate bending moments applied to the retainer ring 3. Accordingly, it is not necessary to enhance the rigidity of the housing 2 to prevent

generation of bending moments. Thus, as shown in FIG. 6, the housing 2 can be thinned so as to be lightweight, thereby improving easiness of maintenance.

FIG. 7 is a vertical cross-sectional view showing a top ring according to a second embodiment of the present invention. As shown in FIG. 7, in the present embodiment, a joint 50 is provided instead of the sliding contact joints in the first embodiment. The joint 50 interconnects an upper member 3a of a retainer ring 3 and a housing 2 and has a sufficient high rigidity in horizontal and vertical directions and a low flexural rigidity. In the present embodiment, in order to have a sufficient high rigidity in horizontal and vertical directions and a low flexural rigidity, the joint 50 has a constricted cross-section such that the width of a vertically central portion thereof is smaller than upper and lower portions thereof. Even with a constricted cross-section, since the joint 50 receives a load in one direction with its perimeter, a sufficient rigidity can be maintained in the horizontal direction. At that time, bending moments are received by the respective cross-sections. As a result, the flexural rigidity becomes lower than the rigidity in the horizontal direction.

In the present embodiment, since the rigidity of the joint 50 is increased in the horizontal and vertical directions, a load can reliably be transmitted from the top ring shaft 11 to the retainer ring 3. Further, since the flexural rigidity of the joint 50 is lowered, a bending moment due to a load applied to the central portion of the housing 2 can be absorbed by the joint 50 to reduce a bending moment applied to the retainer ring 3. Accordingly, it is possible to prevent inclination of the retainer ring 3 and reduce partial wear of the lower surface of the retainer ring 3. In the present embodiment, the housing 2, the joint 50, and the upper member 3a of the retainer ring 3 are formed integrally with each other. However, the present invention is not

limited to this example.

As described above, the joint 50 having a low flexural rigidity can reduce a bending moment applied to the retainer ring 3. As shown in FIG. 7, when the joint 50 is disposed outside of the center of the radial width of the retainer ring 3, it is possible to further reduce a bending moment applied to the retainer ring 3. Specifically, when the joint 50 is disposed outside of the center of the radial width of the retainer ring 3, a load of the top ring shaft 11 is applied to a portion located outside of the center of the radial width of the retainer ring 3 as shown in FIG. 8. Accordingly, a bending moment M_1 is produced with respect to the center of the width of the retainer ring 3. This bending moment M_1 cancels a bending moment M_2 produced by a load applied to the central portion of the housing 2. Thus, a bending moment applied to the retainer ring 3 can further be reduced. Accordingly, it is possible to reduce partial wear of the lower surface of the retainer ring 3 more effectively.

In the present embodiment, one end of a pressurizing sheet 23 is clamped between the upper member 3a of the retainer ring 3 and a pressurizing sheet support 3d provided radially inward of the upper member 3a but may be fixed to the housing 2 as with the first embodiment.

FIG. 9 is a vertical cross-sectional view showing a top ring 301 according to a third embodiment of the present invention. As shown in FIG. 9, the top ring 301 has a housing 302 and a retainer ring 303 attached to a lower end of a peripheral edge portion of the housing 302. The housing 302 is made of a material having high strength and rigidity, such as metal or ceramics. The housing 302 has a housing body 302a in the form of a cylindrical receptacle and an annular pressurizing sheet support 302b fitted inside of a cylindrical portion of the housing body 302a. The retainer ring 303 is fixed to a lower end of the housing body 302a of the housing 302 by

bolts 308.

The top ring shaft 311 is disposed above a central portion of the housing body 302a of the housing 302, and the housing 302 is coupled to the top ring shaft 311 by the universal joint 310. The universal joint 310 has a spherical bearing mechanism by which the housing 302 and the top ring shaft 311 are tiltable with respect to each other, and a rotation transmitting mechanism for transmitting rotation of the top ring shaft 311 to the housing 302. These mechanisms transmit a pressing force and a rotating force from the top ring shaft 311 to the housing 302 while allowing the housing 302 and the top ring shaft 311 to be tilted with respect to each other.

The spherical bearing mechanism includes a hemispherical recess 311a defined centrally in a lower surface of the top ring shaft 311, a hemispherical recess 302c defined centrally in an upper surface of the housing body 302a, and a bearing ball 312 made of a highly hard material such as ceramics and interposed between the recesses 311a and 302c. Meanwhile, the rotation transmitting mechanism includes drive pins (not shown) fixed to the top ring shaft 311 and driven pins (not shown) fixed to the housing body 302a. Even if the housing 302 is tilted with respect to the top ring shaft 311, the drive pins and the driven pins remain in engagement with each other while contact points are displaced because the drive pin and the driven pin are vertically movable relative to each other. Thus, the rotation transmitting mechanism reliably transmits rotational torque of the top ring shaft 311 to the housing 302.

The housing 302 and the retainer ring 303 attached to the housing 302 have a space defined therein, which accommodates therein an elastic pad 304 brought into contact with a semiconductor wafer W, to be polished, held by the top ring 301, an annular holder ring 305, annular elastic pad supports 309 and 313 for supporting the elastic pad 304, and a chucking plate 306

substantially in the form of a disk for supporting the elastic pad supports 309 and 313. The elastic pad 304 has a radially outer edge clamped between the chucking plate 306 and the elastic pad supports 309 and 313 and covers lower surfaces of the elastic pad supports 309 and 313.

A pressurizing sheet 307 comprising an elastic membrane extends between the holder ring 305 and the housing 302. The pressurizing sheet 307 has one end clamped between the housing body 302a of the housing 302 and the pressurizing sheet support 302b and another end clamped between an upper end portion of the holder ring 305 and the chucking plate 306. The housing 302, the chucking plate 306, the holder ring 305, and the pressurizing sheet 307 jointly define a pressure chamber 314 in the housing 302.

An end of a fluid passage 315 such as a pipe is opened to the pressure chamber 314. The fluid passage 315 is connected to a compressed air source via a selector valve or a regulator, which is not shown. Ends of fluid passages 316 and 319 such as pipes are opened to a lower surface of the chucking plate 306. The fluid passages 316 and 319 are connected to the compressed air source via a selector valve or a regulator, which is not shown. Further, fluid passages 317 and 318 such as pipes are opened to lower surfaces of the elastic pad supports 309 and 313. The fluid passages 317 and 318 are connected to a vacuum source and the compressed air source via a selector valve or a regulator, which is not shown.

By depressurizing the lower surfaces of the elastic pad supports 309 and 313 via the fluid passage 318, a semiconductor wafer W is attracted to and held on the lower surfaces of the elastic pad supports 309 and 313. While the top ring 301 is rotated, the semiconductor wafer W attracted to and held on the lower surface of the housing 302 is pressed against the polishing surface (the upper surface of the polishing pad) 321 on the rotating polishing

table 320. Thus, the semiconductor wafer W is polished by relative movement between the semiconductor wafer W and the polishing surface 321. At that time, compressed air is supplied to the pressure chamber 314 and between the lower surface of the chucking plate 306 and the semiconductor wafer W via the fluid passages 315, 316, 317, 318, and 319. Pressing forces to press the semiconductor wafer W against the polishing surface 321 on the polishing table 320 are adjusted by adjustment of pressures.

FIG. 10A is a vertical cross-sectional view showing an attachment portion of the retainer ring 303 in the top ring 301, and FIG. 10B is a view showing a surface pressure distribution in the retainer ring 303. As shown in FIGS. 10A and 10B, the retainer ring 303 has a first ring member 331 made of resin and a second ring member 332 made of metal or ceramics which has substantially the same plane shape as the first ring member 331. The first ring member 331 is fastened to a lower surface of the second ring member 332 by bolts 333.

An annular groove 332a is formed in the lower surface of the second ring member 332. The first ring member 331 has an annular projection 331a formed on its upper surface which can fit into the groove 332a.

Specifically, the retainer ring 303 has an engagement portion to engage the first ring member 331 and the second ring member 332 with each other. This arrangement facilitates attachment of the first ring member 331 to the second ring member 332 and strengthens fastening of these members. Such an engagement portion may be eliminated. Instead of the engagement portion, a pin may be used to fix the first ring member 331 and the second ring member 332 to each other.

Polyetheretherketone (PEEK), polyphenylene sulfide (PPS), full aromatic polyimide resin, which is refractory plastics, or polycarbonate resin can be used as the resin for the first ring member 331 of the retainer ring 303.

It is desirable that the first ring member 331, which is brought into contact with the polishing surface 321, contains particles serving as abrasive particles when being scraped or particles that cause no damage to a semiconductor wafer. The second ring member 332 is made of metal such as titanium or stainless, or ceramics such as alumina so as to achieve good heat transfer from the first ring member 331. Preferably, the bolts 333, which fasten the first ring member 331 and the second ring member 332, may be made of a material having a thermal expansion coefficient close to that of resin of the first ring member 331 or metal (titanium or stainless) or ceramics of the second ring member 332.

In order to achieve good heat transfer from the first ring member 331 to the second ring member 332, it is desirable to enlarge a contact area at the interface. A material having a high thermal expansion coefficient may preferably be used for the bolts 333. Further, as shown in FIG. 11, a plurality of bolts 333 may be provided at predetermined pitches along a circumference to fasten the first ring member 331 and the second ring member 332 to each other. Alternatively, as shown in FIG. 12, a plurality of bolts 333 may be provided at predetermined pitches along two circumferences.

When the top ring 301 including the retainer ring 303 having a structure shown in FIG. 10A is pressed against the polishing surface 321 on the polishing table 320 under a pressing force F, as shown in FIG. 10B, surface pressures P on the lower surface of the first ring member 331 of the retainer ring 303 has a distribution which is slightly small at an inner portion A of the first ring member 331 but is substantially uniform from an outer portion to the inner portion.

FIG. 13A is a vertical cross-sectional view showing an attachment portion of a retainer ring 440 in a conventional top ring 401 to compare

operational effects with the retainer ring 303 having a structure shown in FIG. 10A. FIG. 13B is a view showing a surface pressure distribution in the retainer ring 440. In the example shown in FIG. 13A, the retainer ring 440 is formed integrally of resin and fastened and fixed to a lower surface of a peripheral portion of the housing 302 by bolts.

Since the retainer ring 440 formed integrally of resin is deformed by fastening forces of the bolts attached to the housing 302, it is necessary to perform a dummy polishing process to remove irregularities on its surface due to deformation after the retainer ring 440 is newly attached to the housing 302. Such a dummy polishing process increases a downtime of the apparatus.

Further, when the top ring 401 including the retainer ring 440 having a structure shown in FIG. 13A is pressed against the polishing surface on the polishing table under a pressing force F, as shown in FIG. 13B, surface pressures P on the lower surface of the retainer ring 440 has a distribution which is substantially uniform from an outer portion to a central portion of the retainer ring 440 but is greatly varied at the inner portion A.

Here, in order to prevent partial wear of the retainer ring, a ring member made of stainless (or titanium, ceramics) and a ring member made of resin may be bonded to each other by an adhesive to form a two-layer structure. Such a retainer ring having a two-layer structure should be discarded due to wear of the ring member made of resin. Accordingly, such a retainer ring suffers high cost for expendables and large environmental loads. Further, aged deterioration of the adhesive or separation due to insufficient adhesion is caused so as to lower the reliability.

In the present embodiment, as shown in FIG. 10A, the retainer ring 303 is configured such that the first ring member 331 and the second ring member 332 are fastened to each other by the bolts 333 to form a two-layer

structure in the vertical direction. Accordingly, it is possible to achieve high reliability of fastening of the first ring member 331 and the second ring member 332 and regenerate the retainer ring 303 merely by replacement of the worn first ring member 331. Further, the engagement portion is formed by forming the annular groove 332a in the lower surface of the second ring member 332 and forming the annular projection 331a, which is fitted into the groove 332a, in the upper surface of the first ring member 331. Accordingly, it is possible to facilitate assembling the retainer ring 303 and further enhance the reliability of fastening of the first ring member 331 and the second ring member 332. Further, since the retainer ring 303 can be regenerated merely by the replacement of the first ring member 331, it is possible to reduce cost for expendables and environment loads.

Further, the retainer ring 303 is configured such that the first ring member 331 is fastened to the lower surface of the second ring member 332 by the assembly bolts 333. Accordingly, when the retainer ring 303 is fastened and fixed to the lower surface of the peripheral portion of the housing 302 by the bolts 308 as shown in FIG. 9, the clamp stress of the bolts 308 is received by the second ring member 332, which has a rigidity higher than the first ring member 331. Thus, the retainer ring 303 is prevented from being deformed. Therefore, it is possible to shorten a period of time (downtime) required for a dummy polishing process to eliminate irregularities of the surface of the retainer ring 303.

In the present embodiment, the first ring member 331 and the second ring member 332 forming the retainer ring 303 are fastened to each other by the bolts 333. However, means for fastening the first ring member 331 and the second ring member 332 to each other is not limited to this example. Various detachable fastening tools may be employed. For example, one of the ring members 331 and 332 may have a step portion having a small

outside diameter, and the other of ring members 332 and 331 may have a recess having a large inside diameter. Externally threaded grooves may be provided in an outer circumferential surface of the step portion having a small outside diameter while internally threaded grooves may be provided in an inner circumferential surface of the recess having a large inside diameter. Thus, the first ring member 331 and the second ring member 332 may be fastened to each other by screwing the externally threaded grooves and the internally threaded grooves on each other. Further, other mechanical fastening tools may be employed.

When the lower surface of the retainer ring is brought into uniform contact with the polishing surface, the retainer ring may block polishing slurry to be supplied from the exterior of the retainer ring so as to make it difficult to supply polishing slurry sufficiently to a workpiece to be polished, which is present inside of the retainer ring. Accordingly, slits may be formed in the lower surface of the retainer ring to supply polishing slurry therethrough to a workpiece to be polished, which is present inside of the retainer ring. However, when slits are formed in a sliding contact surface of the retainer ring, polishing properties vary in a circumferential direction between portions having the slits and portions having no slits. A retainer ring according to the following embodiments can prevent such drawbacks.

FIG. 14 is a vertical cross-sectional view showing a top ring 510 according to a fourth embodiment of the present invention. The top ring 510 holds a semiconductor wafer W as a workpiece to be polished, press the semiconductor wafer W against the polishing surface on the polishing pad 522, and bring the semiconductor wafer W into sliding contact with the polishing surface to conduct chemical mechanical polishing. Specifically, the top ring 510 has a retainer ring 512 provided on a lower surface of a housing 511 so that a peripheral edge portion of the semiconductor wafer W is held by an

inner circumferential surface of the retainer ring 512. Further, a plate 515 is disposed within the housing 511 in a state such that the plate 515 is movable in a vertical direction via an elastic body ring 514. A pressing force to press the semiconductor wafer W against the polishing surface is adjusted by adjusting an air pressure of a pressure chamber 513, which is surrounded by the plate 515 and the housing 511. Accordingly, while the semiconductor wafer W is held and pressed by the top ring 510, it is brought into sliding contact with the polishing surface of the polishing pad 522 fixed on a polishing table 521. Chemical mechanical polishing is conducted by supplying polishing slurry to the polishing surface.

As shown in FIG. 14, a notch 512a extending radially inward is formed in an outer circumferential surface of the retainer ring 512. The retainer ring 512 is formed of, for example, plastic resin. The notch 512a, which has a width of about 0.5 mm to about 1 mm (in a height direction of the retainer ring 512), is formed along its perimeter in the present embodiment. It is desirable that the (radial) depth of the notch 512a is set to be about 2/3 of the (radial) width of the retainer ring 512. As a matter of course, the width and depth of the notch 512a are properly determined according to the size, material, and the like of the entire retainer ring. Further, it is not necessary to form the notch 512a along its perimeter, and the notch 512a may partially be formed.

With the notch 512a extending radially inward on the outer circumferential surface of the retainer ring 512, the rigidity in the vertical direction with respect to the lower surface of the retainer ring 512 can gradually be reduced toward its periphery. Thus, an area having a low surface pressure is disposed at a peripheral portion of the lower surface of the retainer ring 512. Specifically, a range in which the top ring has a low pressing force is provided. Accordingly, polishing slurry can readily be

introduced into an inner side of the retainer ring 512. Once the polishing slurry has been introduced into the inner side of the retainer ring 512, it does not flow out of the retainer ring 512 with ease. Thus, it is possible to increase the amount of polishing slurry supplied to a workpiece held inside of the retainer ring 512.

As shown in FIG. 15, it is desirable to fill the notch 512a with an elastic member 519, such as rubber, by molding or the like. When the notch 512a is filled with the elastic member 519, polishing slurry is prevented from being introduced into the notch 512a and being fixed therein. Thus, it is possible to prevent troubles due to long-term use of the top ring. Further, since the elastic member 519 such as rubber is filled, reduction of the rigidity is not inhibited at the peripheral portion of the top ring.

Further, as shown in FIG. 16, the notch 512a may be formed at a boundary portion of a lower surface of the housing 511 disposed above the retainer ring 512. Specifically, a non-contact portion (notch) 512a is provided outside of a joint portion between the retainer ring 512 and the housing 511. Accordingly, the rigidity of the retainer ring 512 in the vertical direction can be reduced toward an outer side of the retainer ring 512. Thus, the surface pressure of the polishing surface on the lower surface of the retainer ring 512 can be reduced toward the outer side of the retainer ring 512. As a result, as in the above case, polishing slurry can be prevented from being introduced into an inner side of the retainer ring 512.

An elastic member such as rubber may be filled into the non-contact portion 512a provided between the lower surface of the housing 511 and the upper surface of the retainer ring 512 as shown in FIG. 16. In this case, as with the elastic member 519 shown in FIG. 15, polishing slurry can be prevented from being introduced into and fixed to the interior of the non-contact portion 512a.

FIG. 17A shows a portion of a top ring 510 according to a fifth embodiment of the present invention. In this top ring 510, an extended portion 512c extending outward is disposed at a bottom portion of a cylindrical retainer ring 512. Because the extended portion 512c is thinner than a thick portion of the retainer ring 512, the extended portion 512c can reduce the vertical rigidity with respect to the lower surface of the retainer ring 512.

FIG. 17B shows a portion of a top ring 510 according to a sixth embodiment of the present invention. The top ring 510 has a notch 512a positioned right above an extended portion 512c. With this arrangement, the vertical rigidity of the retainer ring 512 can further be reduced toward an outer side of the retainer ring 512 as compared to the structure of the extended portion shown in FIG. 17A.

For example, the extended portion 512c shown in FIGS. 17A and 17B preferably has a thickness of about 1 mm to about 2 mm and a radial length of about 5mm. When the notch 512a is formed as shown in FIG. 17B, it is desirable that the extended portion 512c has a width of about 0.5 mm to about 1 mm and a (radial) length that is about 2/3 of a (radial) width of the retainer ring as described above. However, these dimensions should be properly changed according to the overall dimension or material of the retainer ring 512. Further, it is not necessary to form the extended portion 512c and the notch 512a along the perimeter of the retainer ring 512, and the extended portion 512c and the notch 512a may partially be provided.

A material used for a portion of the retainer ring 512 which is brought into contact with the polishing surface may be different from a material used for a portion of the retainer ring 512 which is brought into contact with the housing 511. FIGS. 18A and 18B show examples in which the retainer ring 512 is formed of a plurality of materials. For example, as shown in FIGS.

18A and 18B, a ring member 512f which is brought into contact with the polishing surface 522 may be made of a corrosion-resistant material, whereas a retainer portion 512d which is brought into contact with the housing 511 may be made of stainless. In such a case, when a notch is formed in an inner circumferential surface of a contacting portion between the ring member 512f and the retainer portion 512d, the surface pressure can be reduced at an outer side of the retainer ring 512.

In this case, as shown in FIG. 18A, an intermediate medium 512e may be provided on bonding surfaces between the ring member 512f and the and the retainer portion 512d. Alternatively, as shown in FIG. 18B, the ring member 512f and the retainer portion 512d may be bonded directly to each other.

FIG. 19 shows a variation of the retainer ring 512 shown in FIG. 14. In this example, a material used for a portion 512h that is reduced in rigidity is more likely to be scraped than a material used for a portion 512g that is not reduced in rigidity. For example, the portion 512h that is reduced in rigidity is made of PPS, and the portion 512g that is not reduced in rigidity is made of PEEK. These portions are bonded to each other. With this arrangement, since the portion 512h having a lower rigidity produces a reduced pressure, a removal rate of the retainer ring 512 becomes lower than the portion 512g that is not reduced in rigidity. When the retainer ring 512 is used for a long term, steps caused by differences of removal rates change a surface pressure distribution of the retainer ring 512. If an initial surface pressure distribution is changed, the amount of slurry to be supplied to a semiconductor wafer is changed. Accordingly, by using a material that is likely to be scraped for the portion 512g having a lower rigidity, it is possible to reduce the differences of the amount of removal.

In the embodiment shown in FIG. 14, even if differences of the

amount of removal are produced, a scraped portion further reduces the rigidity of a portion that is not scraped. Specifically, by optimizing the positional height and depth of the notch 512a, a variation of the surface pressure can be reduced even if differences of the amount of removal are produced in the case of the same material.

In the examples shown in FIGS. 18A and 18B, a portion having a high rigidity is first scraped so that a high surface pressure is applied to a portion that is not scraped. Accordingly, a uniform distribution of the amount of removal can be achieved by properly designing the size of the notch 512a.

FIG. 20 is a graph showing a surface pressure distribution in the retainer ring 512 shown in FIG. 17B. For example, in the retainer ring 512 shown in FIG. 17B, the surface pressure distribution is highest on an inner surface R_0 of the retainer ring 512. The surface pressure distribution is lowered on an outer surface R_1 of the retainer ring 512 by interaction of the notch 512a and the extended portion 512c. The surface pressure is further reduced on an outer surface R_2 of the extended portion 512c.

Accordingly, the semiconductor wafer W to be polished and the lower surface of the retainer ring 512 are brought into sliding contact with the polishing surface 522 between the rotating top ring 510 and the polishing surface 522 on the rotating and/or revolving polishing pad 522. Polishing slurry supplied to a central portion of the polishing pad 522, which is not shown, or a portion of the polishing pad 522 near a peripheral portion of the retainer ring 512 from a nozzle is introduced between the lower surface of the retainer ring 512 and the polishing surface of the polishing pad 522 from the peripheral portion of the retainer ring 512 which has a low surface pressure. Thus, the polishing slurry can readily be supplied to the interior of the retainer ring 512. Specifically, polishing slurry can be supplied uniformly to the interior of the retainer ring by provision of a portion having a low surface

pressure along the perimeter of the retainer ring 512. Accordingly, polishing slurry can be supplied uniformly to the entire surface of the semiconductor wafer W to be polished. Thus, uniform polishing properties can be obtained.

When polishing slurry is supplied to an upper surface (polishing surface) of the polishing pad 522 from a rear face of the polishing pad 522 through one or more openings provided in at least portions of the polishing pad 522 which are brought into contact with the semiconductor wafer W, used polishing slurry can satisfactorily be discharged from the surface of the semiconductor wafer W toward the peripheral portion of the retainer ring 512 by effect of the retainer ring 512 having the notch 512a as described above. Accordingly, since new polishing slurry is continuously supplied uniformly to the entire surface of the surface of the semiconductor wafer W to be polished, uniform polishing properties can be obtained. Such a method of supplying polishing slurry is suitable for a revolving polishing pad (having a radius e) or a case in which the top ring 510 passes through a central portion of a rotating polishing pad 522.

Further, a slit having a size and a shape such that it does not cancel the aforementioned surface pressure gradient effect of the retainer ring 512 due to the notch 512a may be provided in a sliding contact surface of the retainer ring so as to promote uniform supply of slurry to the surface to be polished.

According to the embodiments, polishing slurry can readily be supplied uniformly to the interior of a retainer ring, which holds a peripheral edge of a workpiece to be polished. Thus, there can be provided a polishing apparatus which has good polishing properties over the entire surface of a surface of a workpiece to be polished.

In the above embodiments, the present invention can be applied to any top ring which holds a peripheral edge portion of a workpiece and bring

the workpiece into sliding contact with a polishing surface. Thus, the present invention is not limited to examples in which the top ring is rotated while the polishing table is rotated. For example, the present invention can be applied to an example in which the top ring holds a workpiece to be polished and make a translational orbital movement with respect to the polishing surface.

The polishing table is employed in the above embodiments. However, the present invention is not limited to a polishing apparatus having a polishing table. The present invention can be applied to any polishing apparatus as long as the polishing apparatus holds a workpiece to be polished by a top ring, presses the workpiece against the polishing surface, and provides a relative movement between the workpiece and the polishing surface to polish the workpiece.

Although certain preferred embodiments of the present invention have been described above, it should be understood that the present invention is not limited to the above embodiments. As a matter of course, various changes may be made therein without departing from the scope of the present invention.

Industrial Applicability

The present invention is suitably used for a polishing apparatus for polishing a workpiece to be polished, such as a semiconductor wafer, by holding the workpiece and pressing the workpiece against a polishing surface.